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Turbinate surgery

Summary
The nose forms the first 8 cm of the upper respiratory tract and, in addition to supplying air, serves to clean, humidify, and temper the inhaled air. This process is referred to as conditioning. The nasal valve region, formed by the head of the inferior turbinate, portions of the cartilaginous septum, and the lateral cartilage, diffuses and accelerates the inhaled air. Prerequisites are proper mucociliary clearance and sufficient air passage. Hypertrophy of the inferior turbinates is one of the most common causes of symptomatic nasal obstruction. Rhinometric procedures provide additional diagnostic support in unclear cases. In addition to conservative treatment of allergic or vasomotor rhinitis using specific immunotherapy or topical corticoids, there are various interventional procedures for reducing the size of the turbinate tissue while maintaining a high degree of protection of the respiratory mucosa.

Keywords
Nasal cavity · Rhinitis · Respiratory disorders · Nasal turbinates · Ablation procedures

Learning objectives

After reading this article, you will be familiar with key aspects of the function, diagnosis, and treatment of diseases involving the nasal turbinates. Then...

- **Do you know the physiology of the nasal turbinates,**
- **can you classify the causes of nasal turbinate hypertrophy,**
- **Do you know about functional diagnostics for nasal breathing difficulties and their Interpretation,**
- **You can find conservative treatment options for nasal turbinate hypertrophy apply,**
- **Are you familiar with surgical treatment options and their advantages and disadvantages?**

Physiology and pathophysiology

The main function of the nose is to condition the air

The human nose is the first part of the upper respiratory tract that inhaled air comes into contact with. The main function of the nose is to condition the air to enable efficient gas exchange in the lungs. Although the nose only comprises about 5–8 cm of the upper respiratory tract, the majority of the conditioning takes place in this short section. This is possible, among other things, because the mucosal surface that comes into contact with the inhaled airflow is considerably larger. The anterior nasal segment, with its**Nasal valve region** is of great importance with regard to**Air conditioning function**to [1]. Due to the high vascularization of the mucosa, heat is transferred to the inhaled air, which leads to an increase in air temperature by 6–8 °C [2,3]. In addition, the inhaled air is moistened by the constant mucous film on the mucosa, which under physiological conditions leads to **Increase in humidity**up to 95%. Inhaled particles settle on the mucous film due to the close contact of the air with the mucous membrane and are removed by the**mucociliary clearance**transported towards the nasopharynx [4,5,6,7].

Modern rhino- and sinus surgery is based on extensive mucosal protection

The essential function of mucociliary clearance, which is enabled by the ciliated epithelium, becomes clear in cases of dysfunction of the same: The rare syndromes of primary ciliary dyskinesia (PCD) or even the full-blown Kartagener syndrome lead, due to a dysfunction of ciliary activity, to severe, therapy-refractory inflammation of the upper and lower respiratory tract [8,9]. This also leads to a**Hypoplasia**of the paranasal sinus system with the absence of the frontal sinus, whose normal growth cannot occur due to disruption of the ciliated epithelium. These clinical pictures illustrate the principle of modern rhino- and sinus surgery, which is based on extensive mucosal preservation.

Nasal turbinate surgery

Abstract

The nose forms the first 8 cm of the upper respiratory tract and is responsible for cleaning, humidification, and temperature control of the supplied air. This is also referred to as conditioning. The nasal valve region, formed by the head of the lower nasal concha, portions of the cartilaginous septum, and the upper lateral cartilage, is responsible for diffusing and accelerating the respiratory airflow. Prerequisites are regular mucociliary clearance and sufficient air passage. Hypertrophy of the lower nasal turbinate is one of the most common causes of symptomatic nasal congestion. In unclear cases, rhinometric procedures are available. In addition to conservative therapy of allergic or vasomotor rhinitis by specific immunotherapy or topical corticoids, numerous interventional procedures are available to reduce conchal tissue. All modern methods have a high degree of protection of the respiratory mucosa in common.

Keywords

Nasal cavity · Rhinitis · Respiration disorders · Turbinates · Ablation techniques

The nasal turbinates are very well perfused organs. In the anterior part, the inferior turbinate is supplied by nasal tributaries from the**facial artery**which also anastomose with branches of the anterior ethmoidal artery. The middle and posterior parts of the turbinate are in turn supplied by branches of the**A. sphenopalatina**from the maxillary artery. This fact is important for the selection of the surgical procedure, so that resection procedures should be avoided in patients with hypertension and/or anticoagulant medication.

In patients receiving anticoagulant therapy, resection procedures should be avoided

The lower part of the nose is responsible for the aforementioned air conditioning. **respiratory ciliated epithelium**In the upper nasal region, medial to the middle turbinate and adjacent to the frontal base, lies the olfactory region with its sensory epithelium. Airflow in the upper nasal regions is significantly slower, allowing the deposition of odor molecules in the olfactory region.

The nasal turbinates increase the mucosal surface area that comes into contact with the inhaled air. The inferior and middle turbinates are always developed, while the superior turbinates are variable, and the superior turbinates are often only rudimentary. The inhaled airflow is divided by the inferior and middle turbinates ("diffuser function") and distributed evenly over the entire mucosal surface of the lower nasal sections. This occurs primarily in the nasal valve region. The head of the inferior turbinate, as part of the nasal valve, is of great importance here.

The superior and uppermost nasal conchae are often variable or only rudimentary

About 80% of the population**cyclical swelling and subsiding**of the nasal turbinates. This occurs separately on each side over a period of several hours and physiologically leads to one turbinate being temporarily enlarged and one turbinate being reduced in size. The swelling leads to an increase in respiratory resistance and thus to a lower "respiratory load" on the mucous membrane on one side. During this phase, the ciliated epithelium regenerates and cleanses, while the reduced-swelling side takes over the main part of conditioning and cleaning the inhaled air. The nasal cycle can be individually recorded using 24-hour rhinomanometry.

The nasal cycle can be individually recorded with a 24-hour rhinomanometry

Physiological hypertrophy can be increased by a number of internal and external influences. Allergens, inhaled toxins, and medications can lead to permanent hypertrophy. This leads to significantly increased respiratory resistance and can cause symptoms such as nasal obstruction.

One often observes**Nasal septal deviation**on the concave side of the septum a **compensatory turbinate hypertrophy**, which, in conjunction with the aforementioned exogenous factors, can also cause nasal breathing obstruction. EH Huizing famously quoted "The septum and the turbinate, they talk to each other." One almost gets the impression that excessively wide cleft spaces are actively reduced by the ingrowth or hypertrophy of turbinate tissue. This can be impressively demonstrated in long-standing **Septal perforations**which are virtually “closed” by a hypertrophy of the middle nasal concha (.**Fig.1**However, radical surgical maneuvers involving the nasal turbinates prevent any form of regeneration and have therefore been abandoned today, except for radical tumor surgery.

Radical operations on the nasal turbinates are now only performed in cases of tumors

Furthermore, the mucosa is an immunological "organ." Although no lymphatic tissue is present in the nose (only in the nasopharynx with the pharyngeal tonsil), nasal secretions contain a high concentration of secretory immunoglobulin A, which binds to inhaled antigens and prevents their adhesion to the nasal mucosa. In addition, the initial steps of complement activation can occur.

A high concentration of secretory immunoglobulin A is found in nasal secretions

According to clinical and scientific findings of recent years, the air conditioning functions of the nose require**narrow gaps**to function optimally. As part of the nasal valve, the head of the inferior turbinate is particularly important here. This fact is increasingly reflected in modern turbinate surgery and forms its theoretical basis.

Diagnostics

As a standard procedure, in cases of nasal obstruction, anterior rhinoscopy is performed after initial anterior rhinoscopy.**Nasal endoscopy**with a 0° or a 30° lens. The additional functionality

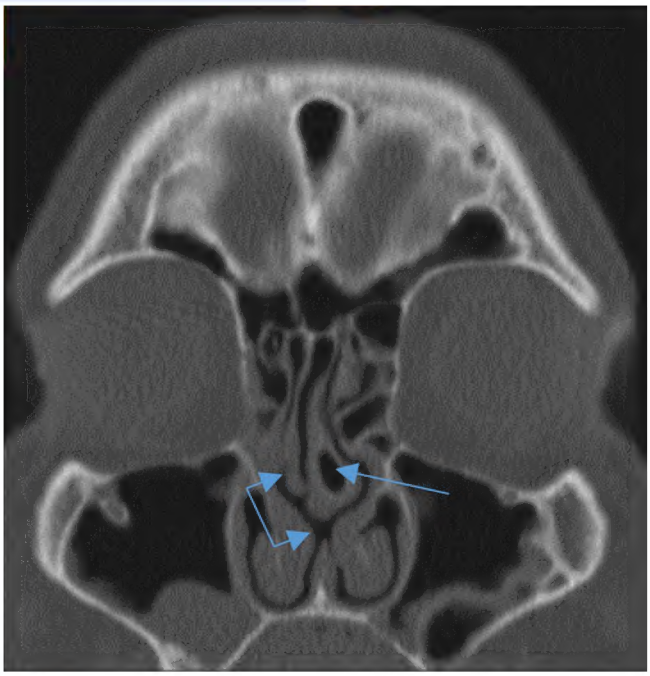

Fig. 1 Coronal CT of a patient with septal perforation (*double arrow*). Inferior turbinates in the chewing M bullosa extends far caudally. with a middle nasal concha that has existed for many years (*Arrow*) as Concha tObliteration of almost the entire perfodal area of the perforation protruding

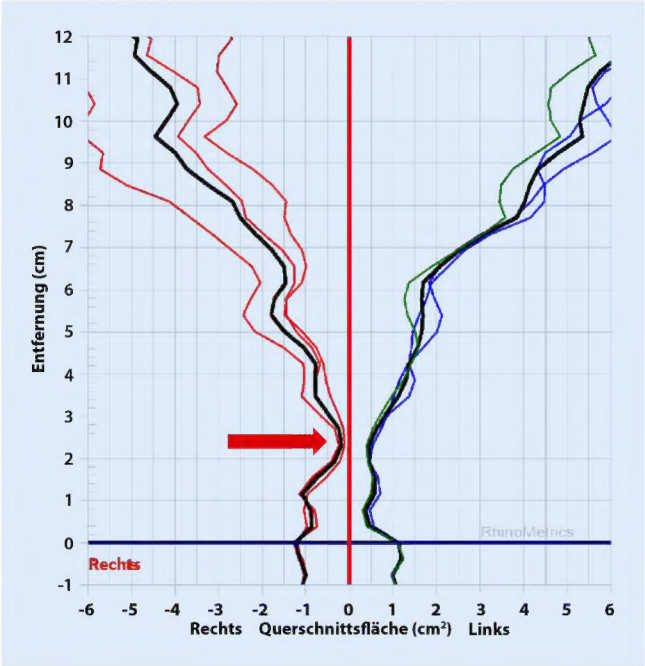

Fig. 2 Result of acoustic rhinometry. Median line (*red line in the center of the image*) and right- or left-deviating lateral nasal wall with calculated cross-sectional area. On the right side at 2.5 cm from the nasal entrance, there is a clear narrowing in the sense of nasal valve stenosis (*Arrow*)

on diagnostics should quantify the symptoms as much as possible. **acoustic rhinometry** uses sound waves to provide a two-dimensional objective cross-sectional image of the nose, which visualizes possible constrictions in the front half of the nose (**Fig. 2**). The experienced clinician can immediately identify nasal constrictions with a quick glance at the diagram. For more detailed evaluation, measurements such as nasal volume or MCA (minimal cross-sectional area) are used, which is the location of the smallest cross-sectional area between 0–2 cm (1) and 2–5 cm (2) from the nasal entrance.

Rhinomanometry is performed using a xylometazoline-containing nasal spray

Rhinomanometry displays the pressure-dependent flow in a diagram, separated by side, before and after decongestion with a xylometazoline-containing nasal spray. By decongesting and comparing the two measurements, a distinction can be made between anatomical obstacles, such as bony and cartilaginous deformities, and the "turbinate factor," i.e., turbinate hypertrophy. If nasal flow improves significantly after decongestion, a **Nasal breathing obstruction** due to a mucosal problem (e.g. turbinate hypertrophy) (**Fig. 3 and 4**). However, this procedure must be described as semi-quantitative because, unlike acoustic rhinometry, it depends on the patient's cooperation.

During inspiration and expiration, flow values of 250 ml/s are required for a good quality of life

The **Rhinoresistometry** represents a further development of rhinomanometry. During two breaths, the flow and resistance at 150 Pa are calculated using an analog-to-digital converter. This allows the nasal airway resistance to be displayed as a function of the breathing rate. The graphical analysis shows at a glance whether the patient is reaching the flow values of 250 ml/s required for a good quality of life during inspiration or expiration with still low resistance, or whether the nasal airway resistance shows a strong (pathological) increase ([10]; **Fig. 5**).

therapy

Various conservative therapies are available depending on the underlying disease. **Intensive nasal mucosa care**, e.g. in rhinitis sicca or an abuse of decongestant nasal sprays ("Privinismus"), usually leads in combination with a topical corticoid over several months and "Privin abstinence" to a significant improvement in symptoms.

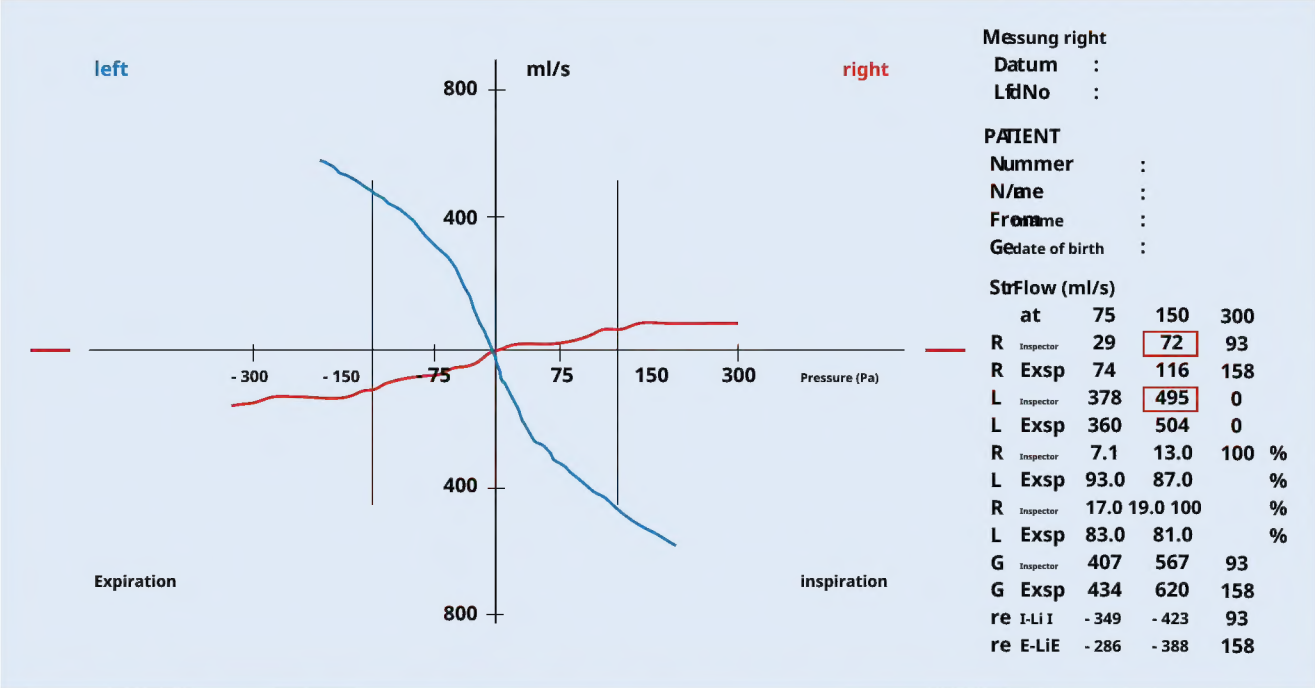

Fig. 38Result of rhinomanometry before application of a xylometazoline-containing nasal spray as a pressure-flow diagram. Nasal obstruction on the right side (*red line*)

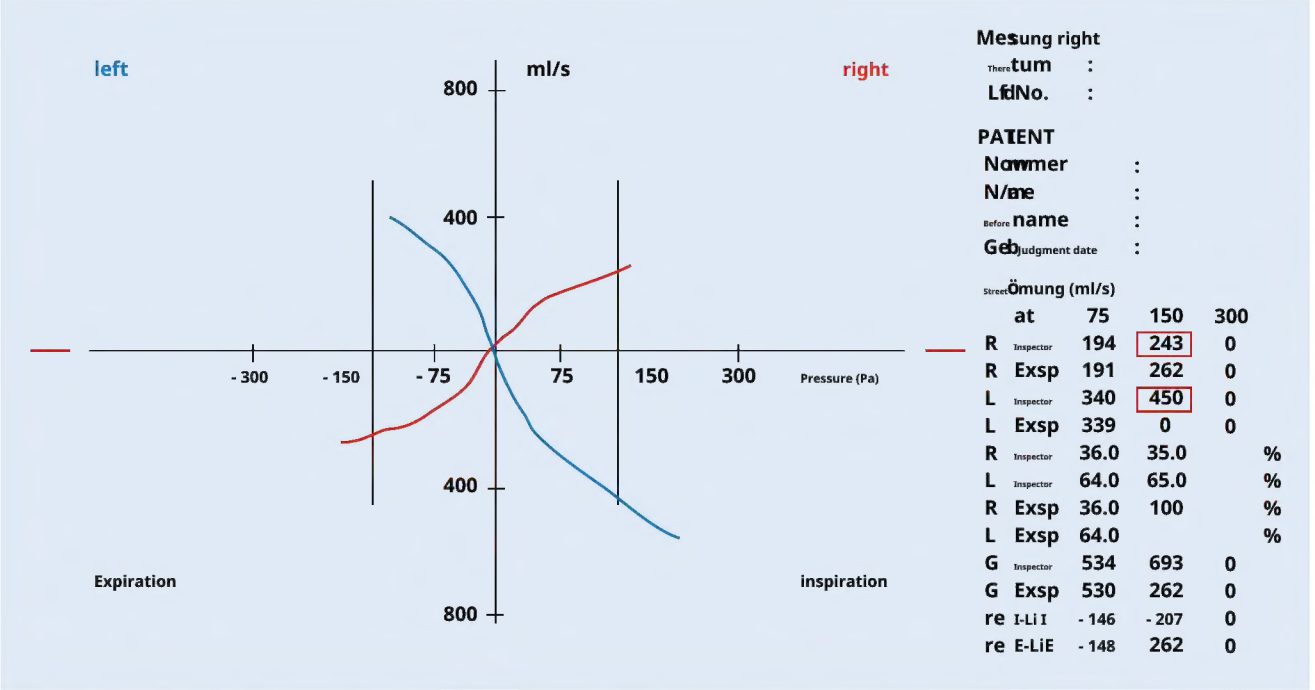

Fig. 48Result of rhinomanometry after application of a xylometazoline-containing nasal spray. Flow is almost symmetrical, possibly indicating a mucosal disease on the right side.

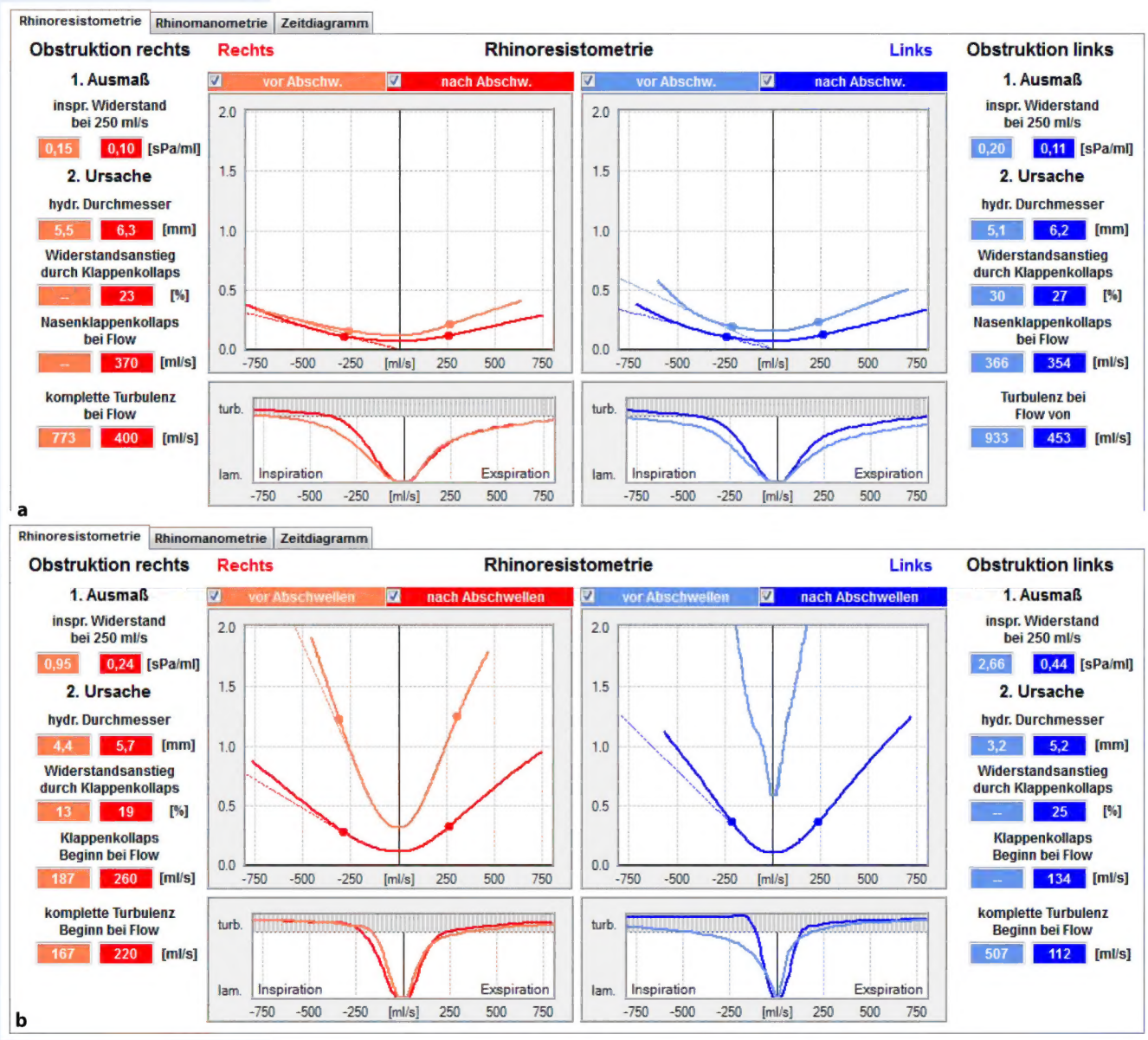

Fig. 5 **a** Normal findings of rhinoresistometry, physiological nasal collapse on the left. **b** Bilateral pathological findings in a tension nose with skeletal stenosis, pathological turbulence, and nasal collapse. (Courtesy of Otoprontᴛᴍ and Prof. G. Mlynski)

In case of allergic symptoms, symptomatic therapies and steroid-containing nasal sprays are indicated

For allergic symptoms, symptomatic topical or systemic therapies in combination with steroid-containing nasal sprays are indicated. In addition, specific immunotherapy can be offered if indicated.

If symptoms persist despite conservative therapy for more than 3 months, surgery may be considered

The current guideline "Nasal breathing difficulties" (S2k guideline "Shape disorders of the inner and outer nose", http://www.awmf.org/leitlinien/detail/ll/017-070.html) provides recommendations for treatment. Clinical symptoms are the primary consideration when planning further treatment. Functional diagnostics provide additional information in cases of ambiguous findings. If symptoms persist despite conservative treatment for at least three months, various surgical treatment options are available to "reduce" the inferior turbinates. A wide variety of procedures have been described over the last 100 years. For clarity, the procedures are divided into two groups:

- thermal and radiofrequency procedures as well as
- surgical-resecting procedures.

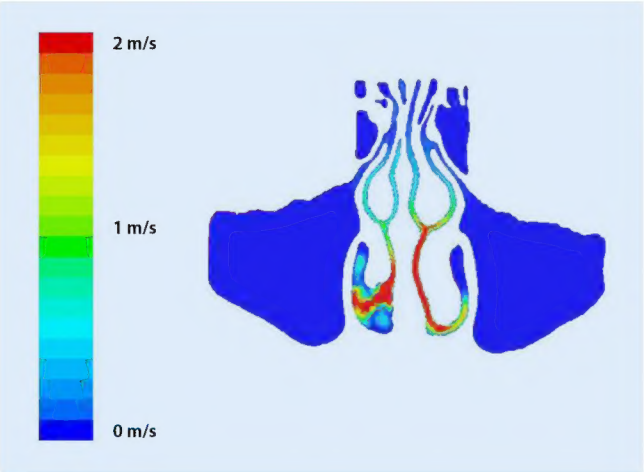

Fig. 69Flow simulation (CF-D simulation, "Computational Fluid Dynamics") of a subtotal inferior turbinate resection on the right. Airflow is mostly caudal to the remainder of the inferior turbinate in the inferior meatus. The cranial nasal portions are significantly less perfused.

Contemporary and common techniques are described.

The first group includes:

- 4Laser surgery,
- 4Radiofrequency ablation and
- 4bipolar caustics.

The second group includes:

- 4Lateralization/lateral fracture,
- 4anterior turbinoplasty,
- 4Shaver-Turbinoplasty and
- 4"Pyriform Turbinoplasty".

Due to extensive turbinate resections in the past, which resulted in secondary**"Empty Nose Syndrome**had led [11,12], surgical treatment is now much more conservative. As much intact mucosa of the turbinate bodies as possible should be preserved. Therefore, almost all treatment methods are based on**submucosal volume reduction**of the turbinate body. The various procedures were investigated in clinical studies and the advantages and disadvantages were analyzed [13]. The previously performed “strip conchotomy” leads to an increased risk of bleeding and severe crust formation with prolonged healing, as well as aerodynamically unfavorable results.

The previously performed “strip conchotomy” leads to aerodynamically unfavourable results

The goal of turbinate surgery is to increase the nasal cross-sectional area in the anterior nasal segment. However, a radical reduction of the inferior turbinate volume leads to a "tunnel-like" airflow, which significantly reduces the contact of inhaled air with the mucosa (. **Fig.6**) and leads to significantly reduced temperature and humidity in the nasopharynx on the affected side.

The aim of turbinate surgery is to increase the nasal cross-sectional area in the anterior nasal segment

Turbinate lasering

A variety of different lasers have already been used in clinical studies. These include the diode laser, the CO_2-Laser, Argon laser, KTP (potassium titanyl phosphate) laser, Nd:YAG and Ho:YAG laser [13,14]. One advantage of laser treatment is its ease of application under local anesthesia and the**low bleeding tendency**and high patient acceptance. Two disadvantages exist: First, the long-term results of this technique are controversial due to the high recurrence rate of turbinate hypertrophy. Furthermore, superficial application of laser energy causes – albeit minor – damage to the mucosal surface, resulting in scarring and impaired mucociliary clearance, which impairs the function of the affected mucosa [13,14However, the procedure can be repeated in an outpatient setting if symptoms recur.

An advantage of laser treatment is its good applicability under local anesthesia

Radiofrequency ablation

RFA causes shrinkage of the cavernous body while the mucosal surface remains intact

During radiofrequency ablation (RFA), a probe is inserted beneath the mucosa at the head of the turbinate and moved submucosally posteriorly along the turbinate body. This is performed with impedance control in multiple applications at 1 cm intervals during retraction. Acoustic impedance control prevents excessive denaturation and heating of the tissue. This results in shrinkage of the corpus cavernosum and the submucosal vascular plexus while leaving the mucosal surface intact. Various studies have shown a similarly high success rate for RFA as mucosa-sparing surgical procedures [15,16,17].The application in**Local anesthesia**is possible, but due to the thick RFA probe, which has to be advanced submucously along the entire turbinate body posteriorly, it can be uncomfortable for the patient in individual cases.

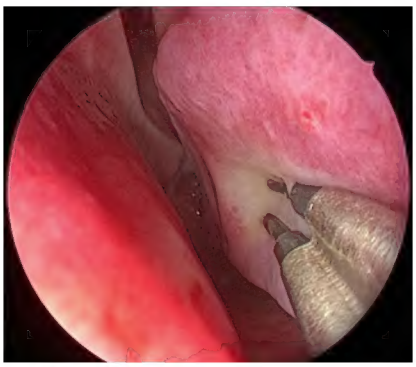

Fig. 78Submucous bipolar cauterization of the inferior turbinate on the left side. Probes inserted into the turbinate body.

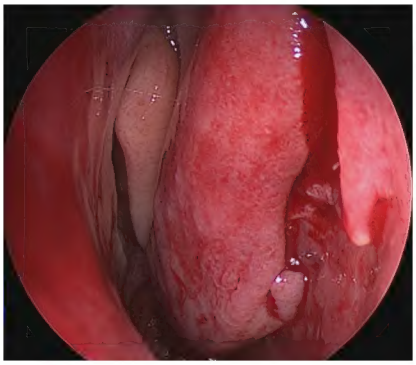

Fig. 88Anterior-inferior turbinoplasty. Repositioning of the medially located mucosal flap over the turbinate head after resection of the lateral, submucosal portion of the turbinate.

Bipolar caustics

Bipolar caustics of the inferior turbinate have also been investigated in many studies [18,19,20]. One advantage is the presence of a generator in each operating room and the**uncomplicated application**The disadvantage of the classic bipolar "forceps" is the risk of superficial**Mucosal damage**similar to laser treatment. However, applicators are now available that are placed submucosally, similar to RFA; however, impedance control is usually missing (.**Fig.7**). The long-term results are also more comparable with laser technology [11].

Lateralization/lateral fracture

Lateralization means lateral mobilization of the os turbinale with a blunt instrument

The simplest surgical procedure for dilating the nasal airway is lateralization or lateral fracture of the inferior turbinate. This involves controlled mobilization of the turbinal bone laterally using a blunt instrument. The effectiveness of this technique has been investigated in smaller studies using CT data sets [21,22]. Furthermore, the technique is often used in combination with other procedures. The technique is safe and uncomplicated to use, but may not be sufficient in cases of pronounced submucosal hypertrophy of the tissue.

Anterior-inferior turbinoplasty

AITP reduces the turbinate volume in the anterior third both bony and submucous

In anterior-inferior turbinoplasty (AITP) [13,23,24] a**vertical mucosal incision**on the turbinate head, extending to the caudal rim of the turbinate. The medially located submucosal tissue, including the mucosa, is elevated from the bony turbinate body. After resecting an anterior-inferior bony and submucosal portion of the turbinate, the initially formed mucosal flap is retracted and the entire inferior turbinate is lateralized (.**Fig.8**). This mucosal-sparing technique, when performed correctly, leaves almost no open wound surface and reduces the turbinate volume in the anterior third, both bony and submucous. The procedure has shown a lasting positive effect on nasal breathing in several studies [11,13,23,24].

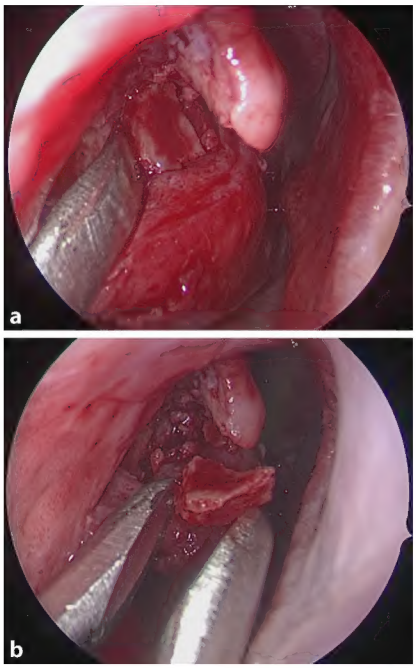

Fig. 9 **a** Submucosal resection of the bony shoulder of the inferior turbinate. **b** Removal of the resected specimen

A very similar, slightly less invasive concept is pursued by the **submucosal resection** [20], in which hypertrophic submucosal tissue and small portions of the turbinal bone are removed through a mucosal incision in the turbinate head. Like AIPT, the procedure is usually combined with lateralization of the turbinate body.

Both techniques are mainly used in **Intubation anesthesia** They are easy to use and are usually performed as part of a septum or septorhinoplasty.

Pyriform Turbinoplasty

The "bony shoulder" of the turbinal bone of the inferior turbinate is resected submucosally

The goal of this technique is the submucosal resection of the "bony shoulder" of the turbinal bone of the inferior turbinate. An incision is made on the lateral nasal wall and anterior to the shoulder of the inferior turbinate. A wide mucosal flap is then dissected inferior and superior to the bony origin of the turbinate, thus providing access to the bone. An osteotome is used to fracture the base of the bony shoulder, and the bone fragment is subsequently dissected free. **Nasolacrimal duct** is located directly behind this fragment and should not be damaged during the procedure. Finally, the mucosal flap is placed over the resection site (. **Fig. 9**).

The advantage of pyriform turbinate plasty lies in the complete preservation of the mucosa and the resection of the inferior turbinate shoulder. The resulting additional gap lateralizes the inferior turbinate and simultaneously expands the nasal valve region without permanently altering nasal flow patterns [25].

Shaver turbinoplasty

The shaver technique is used to resect hypertrophic tissue of the inferior turbinate

Shaver turbinoplasty or microdebrider turbinoplasty was first described by Van Delden in 1999 [26]. The good and safe feasibility with very good long-term results was demonstrated in prospective studies and a meta-analysis [27]. The shaver or microdebrider technique is used to resect hypertrophic tissue of the inferior turbinate in a controlled and gentle submucosal manner. Complications include secondary bleeding, crusting, and **Synechia formation** described in a small proportion of patients. The disadvantage of the procedure is the higher cost, which is why it is usually recommended for sinus surgeries, where the shaver is already used.

outlook

Turbinate hypertrophy can result from hypertrophy of the bone or soft tissue

The treatment of nasal turbinate hypertrophy to improve **Nasal breathing** represents an important aspect of ENT medicine. Treatment of the underlying disease is the primary focus. If symptoms persist, a variety of interventional procedures are available. When selecting a technique, it should be considered that turbinate hypertrophy can result from hypertrophy of the bone and/or soft tissue.

All modern procedures for the treatment of turbinate hypertrophy should share a common principle: maximum protection of the respiratory mucosa and preservation of mucociliary clearance, as well as strict avoidance of radical surgical interventions or extensive mucosal alterations. The optimal procedure for each patient and each side of the turbinate is selected individually, depending on the anatomical conditions.

Conclusion for practice

- **Nasal concha hypertrophies are diagnosed based on anamnesis, clinical examination including nasal endoscopy and rhinological functional diagnostics.**
- **Allergy testing is indicated if the medical history is positive.**
- **Treatment of the underlying disease (e.g. through specific immunotherapy) is of primary importance.**
- **In case of nasal spray abuse, its use should be tapered off and followed by a topical Steroid therapy can be combined.**
- **If conservative treatment fails, surgery should be considered.**
- **The following parameters should be considered when selecting the surgical technique:**
  - **Planning a procedure under local anesthesia? Laser ablation or RFA, bipolar**
  - **cauterization. Surgery as part of a septoplasty, septorhinoplasty, or sinus surgery: submucosal resection, AITP, shaver turbinoplasty, RFA, pyriform turbinoplasty.**
- **All procedures can be combined with lateral fracturing, which can be used in cases of mild pronounced forms alone may be sufficient.**

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Compliance with ethical guidelines

Conflict of interest. F. Sommer, J. Lindemann, M.-O. Scheithauer, T.K. Hoffmann, and J.A. Veit declare that no conflict of interest exists.

This article does not contain any studies on humans or animals conducted by the authors.

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?Which of the following diseases must be considered in differential diagnostic considerations in cases of recurrent sinusitis *the least* be included?

- ◯ nasal polyposis
- ◯ cystic fibrosis
- ◯ Kartagener syndrome
- ◯ Fungal infection
- ◯ M. Cushing

?Which of the listed points hears *not* What are the main functions of the nasal conchae?

- ◯ Regulation of intranasal airflow
- ◯ Warming of the inhaled air
- ◯ Purification of the inhaled air
- ◯ Absorption of fragrance particles
- ◯ Humidification of the inhaled air

?What statement about anatomy and Physiology of the nasal turbinates is correct?

- ◯ The inferior nasal turbinates are perfused by branches of the sphenopalatine artery and facial artery, among others.
- ◯ The uppermost nasal concha is always completely present.
- ◯ The two inferior nasal conchae usually show a slight degree of size variation when compared side by side.
- ◯ The nasal cycle with alternating swelling and shrinkage of the inferior nasal turbinates is present in only a few people.
- ◯ The conditioning of the breathing air takes place on the surface of the nasal mucosa, but the first antibody-antigen reactions only occur in the area of the pharyngeal tonsil.

?Which procedure is used in the context of rhinological diagnostics *not* used routinely?

- ◯ Active anterior rhinomanometry
- ◯ Acoustic rhinometry
- ◯ Nasal endoscopy
- ◯ Virtual flow simulation based on CT data sets
- ◯ Rhinoresistometry

?What statement on rhinological Diagnosis correct?

- ◯ Active anterior rhinomanometry is an objective test procedure.
- ◯ Acoustic rhinometry is a semi-objective procedure.
- ◯ The test results can be distorted by an acute respiratory infection.
- ◯ Rhinoresistometry is the oldest known method and can provide information on turbulent and laminar flow of respiratory air depending on the flow velocity.
- ◯ All three rhinometric procedures mentioned (active anterior rhinometry, acoustic rhinometry, rhinoresistometry) should always be used.

?A 34-year-old patient presents for the first time due to year-round nasal breathing difficulties. What further steps should the patient *not* offered?

- ◯ Nasal endoscopy
- ◯ Rhinomanometry/rhinoresistometry
- ◯ Allergic diagnostics
- ◯ Topical steroid
- ◯ Turbinate lasering

?Which method for reducing of nasal turbinate hypertrophy would be best suited for high-risk patients with arterial hypertension and antiaggregation therapy?

- ◯ Anterior turbinoplasty
- ◯ Radiofrequency ablation
- ◯ "Pyriform turbinoplasty
- ◯ Submucosal resection
- ◯ Microdebrider turbineplasty (shaver)

?Which of the following statements about Treatment of symptomatic nasal obstruction *the least* to?

- ◯ Before interventional therapy, a comprehensive ENT specialist examination should be carried out.
- ◯ In addition to rhinological testing procedures, allergological testing procedures are also used.
- ◯ Overtreatment with too radical resection or thermal ablation can lead to irreversible damage to nasal function.
- ◯ Both inferior turbinates should always be treated identically (e.g. turbinoplasty).
- ◯ The selection of a therapeutic procedure should take into account the individual patient wishes and circumstances.

?Which of the following statements therapeutic procedures on the inferior turbinate?

- ◯ Submucosal/thermal procedures and surgical-resective procedures carry the same risk of impaired wound healing.

- ◯ Laser treatment of the nasal turbinate can be repeated if nasal breathing obstruction occurs again.
- ◯ Lateral fracturing must always be combined with another procedure.
- ◯ Strip conchotomy is the standard procedure in Germany.
- ◯ Bleeding and synechia formation do not occur as complications after shaver turbinoplasty.

?Which of the following procedures aims *not* on a submucosal reduction of the turbinate tissue?

- ◯ "Pyriform turbinoplasty
- ◯ Anterior-inferior turbinate plasty
- ◯ Strip conchotomy
- ◯ Radiofrequency ablation
- ◯ Microdebrider turbineplasty (shaver)

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